3.0 BIG RIVER GEOMORPHOLOGY

Big River geomorphology and stream habitat have changed significantly during the last one hundred years due to human modifications including: channel spanning log jam removal (Kramer, 1953), permanent riparian clearing for agriculture, channel relocation for agriculture, riparian conifer timber harvest and resultant loss of wood recruitment, and floodplain road construction. Subsequently, down-cutting and incisement of the channel have reduced proper floodplain function and a reduction in floodplain connectivity in some reaches, and in other reaches lateral migration has been accelerated. As the channel has incised and the profile lowered in elevation, the ambient groundwater table has also been lowered, resulting in reduced wetland areas and reduced connection to floodplain areas. The compounded effect has been to reduce floodplain storage and seasonally low stream flows in a system used by sockeye salmon that are listed as threatened under the Endangered Species Act.

Theoretical estimates of the degree to which streamflow baseflows might be supported by the drainage of ambient groundwater stored in the unconsolidated sediments of the floodplain were presented in Section 2.3.2. Assumptions used were:

- Aquifer area: 2.5 square miles;
- Workable unsaturated zone: 5 feet;
- Period of release of stored water: Continuous over three months; and,
- Amount of streamflow augmentation: 9 cfs.

The assumption that groundwater is released from bank storage at a constant rate over 90 days is a highly idealized representation. Actual augmentation discharge will be highest at the start of the augmentation period, immediately after recharge is stopped, and will decline over the duration of the augmentation period. This decay in streamflow augmentation will result in the lowest augmentation occurring late in the summer season, during natural low flows, just when it is most needed.

This method of estimating streamflow augmentation provides a theoretical maximum to frame the range that may be attained. The amount of streamflow augmentation that may be achieved by seasonally increasing floodplain storage can also be used as a surrogate to represent the amount of baseflow that is lost as a result of lost floodplain storage. Downcutting of the stream channel accelerates drainage of the floodplain and exacerbates late summer low flows. With this in mind, grade control of the stream channel where it has downcut may result in the restoration of higher summer baseflows.

This assessment reviews and discusses geomorphic channel characteristics within the project area to gain a better understanding for how conceptual in-channel changes may perform and/or mitigate for losses in habitat quality. The assessment focuses on defining geomorphic characteristics on a *reach scale*, recognizing that changes at one location may have effects up- or downstream of a given site. By understanding the behavior of the Big River at the reach scale, we hope to better evaluate and discuss potential improvements that minimize detrimental impacts to up- and downstream properties.

The project area is defined as including the Big River channel from the confluence with Lake Ozette at River Mile (RM) 0 and extending upstream approximately 15 miles to the headwaters. Reach breaks within the study area were defined based on geomorphic channel characteristics (Figure 3-1):

Big River Reaches

Reach Name	River Mile (RM)
Headwaters	~15 to ~11
Falls	~11 to ~10
Boe Creek	~10 to ~6.5
Solberg Creek	~6.5 to ~5
Highway	~5 to ~2
Lake	~2 to 0

The goal of this assessment is to develop a framework for continued planning efforts in the Big River basin that looks at the issues at a reach scale. The existing information was reviewed and organized to define and explain reach scale riverine processes and geomorphic characteristics, and thereby support continued efforts to improve water storage and/or plan, design, and implement habitat enhancement projects. This assessment was completed based on existing available information, studies, mapping, or data. No new additional information was developed or new data acquired through field investigations or site specific analyses. As such, a secondary goal of this assessment is to identify gaps in the existing data and outline approaches for addressing future data needs. This effort may be used as a model for assessing additional drainages throughout WRIA 20.

3.1 Background Information/Data

Existing background data and information was acquired and reviewed to develop an understanding for channel dynamics and basin characteristics in the Big River basin. The following is a summary of the available information.

- **Literature Addressing Bank Storage.** Various papers addressing storage of flows in overbank and wetland areas, as well as channel dynamics relative to in-stream flows are listed in the bibliography section of this report. These papers were reviewed and the concepts incorporated where applicable (Bunn and Arthington, 2002; Hatten, 1996; Naiman and others, 2002; Poff and others, 1997; Poff and others, 2003; Richter and others, 1996; Richter and others, 1997; Richter and others, 2002; and, Silk and others, 2000)]. The bibliography is intended to provide a resource list for continued future efforts to plan, design, and implement projects in the Big River and other drainages. As such, we view the bibliography as a "living document" that will continue to expand as more information is acquired and incorporated into the database.

- **Big River Flow Discharge Data.** The Makah Tribe installed a continuously recording stream flow and water quality (i.e., turbidity) gaging station in November of 2003. The station period of record extends from November 4, 2003 to the present. The gage is located upstream of the Trout and Dunham Creek tributaries at the Big River Bridge (Coordinates: 124 degrees, 33', 56.38" W, 48 degrees, 8' 53.25"N). The station is comprised of an Ott Nimbus Pressure Bubbler/Level Sensor. Periodic discharge measurements are made for maintenance of the rating curve.

- **Aerial Photographs and Mapping Coverages**. The following is a summary of available historical photo and mapping resources:

- o Log jam locations that were removed in the 1950's were digitized from maps contained in (Kramer, 1953; Figure 3-1, Appendix 3-B).

- o Partial 2003 LiDAR coverage of the Big River drainage was received from the Makah Tribe (approximately RM 0 through RM 8; Figure 3-2).

- o Orthophoto coverage, including:
  - Partial coverage of the drainage in 2003 (Figure 3-3);
  - Complete coverage of the drainage in 2000 (Figure 3-4); and,
  - Complete coverage of the drainage in 1994 (Figure 3-5).

- o River mile markers at one mile increments were generated using Big River stream channel topographic data from the Department of Natural Resources.

- o Big River Drainage boundary is based on USGS fifth field Hydrologic Unit Codes (HUC) and modified to reflect the Big River drainage area.

- o Channel Migration Zone (CMZ) boundaries were obtained from Clallam County

- o Wetlands boundaries received from Clallam County

- o Historical stream channel locations of Big River, including:
  - 1996 – GIS coverage from the Department of Natural Resources accurate to +/- 40 ft.
  - 1956/1957 – Digitized and rectified from historic Lake Ozette and Lake Pleasant USGS topographic maps (1:62,500).
  - 1942/1935 – Digitized and rectified from historic Lake Ozette and Lake Pleasant USGS topographic maps (1:62,500).

- o Makah Tribe Stream Gauge locations received from the Makah Tribe.

- o Toe Width Station location received from the Washington Department of Fish and Wildlife (WDFW).

- o Property Ownership boundaries received from Clallam County.

- o Lakes coverage received from the Washington State Department of Ecology.

- o Federal Emergency Management Agency (FEMA) Floodplain boundaries received through the U.S. Department of Agriculture; data originates with FEMA, and is derived from Flood Insurance Rate Maps (FIRM) maps.

- o Base topography from USGS 1:24,000 quadrangles.

- o Hill shade overlying topography derived from USGS 10-meter Digital Elevation Model (DEM) coverage.

- **Mid-Project Meeting**. A mid-project review meeting was held on April 25, 2005 to consolidate information and discuss basin and channel specific issues. In attendance were Ed Bowen (local resident), Jeff Shellberg (Makah Tribe), Chris Pitre (Golder), and Andreas

Kammereck (Golder). The purpose of the meeting was to gain insights on Big River geomorphology from local resources, review the definition of channel reach designations, and discuss how channel features and dynamics interacted within the project area. Jeff Shellberg provided photographs of the Big River. Selected photographs are shown in Appendix 3-A for locations at approximately RM 0, 1.8, 2.5, 4.7, and 7.9.

- **Relevant Background Documents.** Several background documents were reviewed and the information incorporated into this assessment. The following lists of some of the more relevant documents. Additional resources are provided in the bibliography section of this report.
  - "Survey Reports of Major Rivers and Streams of Northwestern Washington with reference to a Stream Improvement Expenditure Program, Part 1 (Clallam County), Compiled by the Division of Stream Improvement, State of Washington, Department of Fisheries", completed by Robert Kramer (Cartographer and Field Technician) in June 1, 1951 (Kramer, 1951). This document focuses on the approach and costs for removing accumulated woody debris from rivers and streams in the Ozette Basin area, including the Big River. The copy of this report obtained is incomplete, and the pages (specifically pages 14 and 15) addressing the Big River are not included in our copy. The report offers insights into how the stream clearing work was scoped and implemented. Further details specific to the Big River can be found in the subsequent follow-up report completed in 1953 that summarizes the work completed under the stream clearing program.
  - "Completion Report by Stream Clearing Unit on Ozette and Big Rivers", completed by Robert Kramer, Supervisor or Stream Clearance Projects, Stream Improvement Division of the Department of Fisheries (April, 1953). This report is the follow-up summary of work completed by the Stream Clearing Unit and offers specific information about work done on the Big River between 1951 and 1953 (Kramer, 1953). The report and applicable maps for the Big River are provided in Appendix 3-B, and includes maps showing the location of woody debris jams that were removed from the Big River as well as some historical photos of the river.
  - "A Catalog of Washington Streams and Salmon Utilization, Volume 2, Coastal, Washington State Department of Fisheries, 1975." (Phinney and Bucknell, 1975). This document provides some insights on salmon utilization (dated) and offers a map of the Big River and some known woody debris locations upstream of Solberg Creek. A copy of the section relevant to Big River is provided in Appendix 3-C.
  - "Lake Ozette Tributary Habitat Conditions", completed by Mike Haggerty and Andy Ritchie for the Makah Tribe (June 2004 final draft version). These documents provide a summary assessment of habitat conditions in the Lake Ozette basin, including information specific to the Big River and some of its tributaries (Haggerty and Ritchie, 2004).

This information is incorporated into the following sections.

3.2 Description of Reach Dynamics

The Lake Ozette basin is located on the northwestern edge of the Olympic Peninsula in Washington State. Lake Ozette is approximately 7,300 acres in size, making it the third largest natural lake in Washington State with a drainage basin area of approximately 77 square miles (Haggerty and Ritchie, 2004). Several significant tributaries drain into Lake Ozette including: Big River, Umbrella Creek, Crooked Creek, Siwash Creek, and South Creek. The Big River is the largest tributary to Lake Ozette (Haggerty and Ritchie, 2004).

The Big River enters the lake at the north end of Swan Bay. The main channel of the Big River is approximately 15 miles long, and the basin area is approximately 22.8 square miles in size (Figure 3-1). The major tributaries to the Big River are (in order of largest to smallest):

- Trout Creek;
- Dunham Creek;
- Solberg Creek;
- Boe Creek;
- Stony Creek;
- An un-named tributary; and,
- Brown Creek (located upstream of the Falls).

A naturally occurring falls at approximately RM 11 is a barrier to anadromous fish passage. The Headwaters Reach above these falls is rugged and steep. The valley below the falls becomes broader and the stream gradient flattens downstream to the confluence with Lake Ozette (Figure 3-6).

The Headwaters Reach above the falls is underlain by Pleistocene age glacial drift and alluvial deposits (Figure 3-7). The northeast side of the valley is bound by topographically steep Eocene age volcanic flows and breccias (of the Crescent Formation). The southwest side of the valley is bounded by slightly less steep Oligocene-Eocene age marine sedimentary rock types. The river drops over the Falls into the lower basin area and meanders across a wide (~0.5 mile wide) valley composed of Pleistocene age glacial till and drift deposits for the reach extending downstream to where it enters Lake Ozette (USGS, 1988; Haggerty and Ritchie, 2004).

The river was broken into several reaches that define changes in geomorphic characteristics. The following is a summary of the location and characteristics of each reach. Reaches are named to reference local features or otherwise designate the governing issues in each reach.

- **Headwaters Reach** (RM 15 – 11). The Headwaters Reach extends from the upper extent of the river channel at approximately RM 15 to the falls at approximately RM 11. The Headwaters is vegetated with conifer tree species, and held in limited land ownership. The Headwaters area has been historically logged, and has existing logging road networks.

- **Falls Reach** (RM 11 - 10). The Falls Reach is a short transition reach and is generally confined with stream gradients ranging up to approximately 3 percent. The upper portion of the reach is defined by a series of naturally occurring waterfalls. The falls define the transition from the Headwaters to the lower basin. Substrate is dominated by gravel, cobbles, and boulders (Haggerty and Ritchie, 2004).

- **Boe Creek Reach** (RM 10 – 6.5). The Boe Creek Reach extends from approximately above the confluence of Boe Creek with Big River to approximately RM 6.5. This reach has experienced the majority of land use changes in the Big River system, and has the greatest concentration of residential and agriculturally developed areas. Riparian vegetation along the river banks has been historically cleared for logging and agricultural purposes. The resulting reduction in near bank large vegetative cover has increased lateral erosion of the river banks. The Boe Creek Reach is defined as a response reach due to the increased potential for lateral and/or vertical changes in channel configuration as a result of changes in flow regime, sediment regime, bank armoring, or other modifications to floodplain features. The channel gradient is generally <1 percent, with occasional sections approaching 2 percent. Sand and pebble materials are common in the lower portions of the reach, while gravel substrate dominates most of the pool tails and riffles (Haggerty and Ritchie, 2004). The lower Boe Creek Reach is one area that experienced the greatest amount of woody debris removal during stream clearance activities in the 1950's (Kramer, 1953; Figure 3-1, Appendix 3-B). Example photos of lateral bank erosion are shown in Appendix 3-A (Photos A-5 through A-7). Photo A-8 shows an example of existing bank armoring in the reach.

- **Solberg Creek Reach** (RM 6.5 – 5). The Solberg Creek reach extends from River Mile 6.5 to approximately River Mile 5, just below the confluence with Solberg Creek. A large majority of the reach is in limited ownership. This reach is a transition reach between the more dynamic upstream Boe Creek Reach and the lower gradient downstream located Highway Reach. The banks of the river are vegetated with large conifers tree species and overbank riparian areas have had limited modifications (e.g., very little logging, agricultural, or other land-use changes). The riparian areas provide sources for woody debris to the river system, as evidenced by the increase of log jams (Haggerty and Ritchie, 2004). The increased woody debris and existing riparian vegetation along the banks of the river have acted to stabilize this reach and limit lateral movement. The channel gradient is generally <1 percent, with occasional sections approaching 2 percent. Sand and pebble materials are common in the lower portions of the reach, while gravel substrate dominates most of the pool tails and riffles (Haggerty and Ritchie, 2004). The Solberg Creek Reach is one area that experienced the greatest amount of woody debris removal during stream clearance activities in the 1950's (Kramer, 1953; Figure 3-1).

- **Highway Reach** (RM 5 – 2). The Highway Reach extends from approximately River Mile 5, just below the confluence with Solberg Creek, to River Mile 2 at the confluence with Trout Creek. This reach is named as such because the highway (Hoko-Ozette Road) located along the rightbank (north side) is perceived to significantly limit channel movement (Golder, 2005b). The river gradient is similar to the Lake Reach (i.e. < 1 percent) due to influence from the lake during winter high water levels. Sediments in this reach include mostly sand and pebbles with occasional gravel patches in the lower half. Gravel becomes more common in locally higher gradient pool tails and glides in the upper half of the reach. This reach lacks developed side channel complexes and sand or gravel bars (Haggerty and Ritchie, 2004). The channel is incised where sands and silts are accumulating, making it relatively stable in its current alignment (Appendix 3-A, Photo A-2). Measured width:depth ratios are low throughout the reach (Haggerty and Ritchie, 2004), which reflects a high degree of channel downcutting (also referred to as incisement and degradation). The Highway reach is one area that experienced the greatest amount of woody debris removal during stream clearance activities in the 1950's (Kramer, 1953; Figure 3-1). The reduction in woody debris complexes accounts for the apparent channel incision. Estimates of vertical drop in channel elevation due to incision range up to approximately 6 feet (Golder, 2005b).

- **Lake Reach** (RM2 – 0). The Lake reach extends over the lowermost two miles of the Big River to its confluence with Lake Ozette (Figure 3-1). The lower reach of the Big River is influenced by backwater from Lake Ozette (Appendix 3-A, Photo A-1). Dunham Creek enters the Big River at approximately RM 1.5. The channel has a low gradient (< 0.2%; Haggerty and Ritchie, 2004). The substrate is mostly fine-grained sediments including silts, sand, and small pebbles. The banks are vegetated, high and steep. The upper portions of this reach are incised (Appendix 3-A, Photo A-2). Woody debris buried in the channel is prevalent throughout the reach. Removal of debris in this reach during clearance efforts in the 1950's was difficult due to limited accessibility, fine grained sediments and backwater from the lake (Kramer, 1953; Figure 3-1).

3.3 Interpretation of Reach Dynamics

Floodplain connectivity is complex and dynamic. A functioning connected channel and floodplain may have one or more of the following components: balance in sediment regime, varied flow regime, overbank riparian areas, relic channels, swales, eroding banks, woody debris, and varied vegetative land covers. Healthy floodplain connectivity requires multiple levels of each of these pieces to work, and may take many years to develop. An understanding for the long-term geomorphic processes in a given system is required to make decisions about proposed projects. Long-term goals can be achieved if the baseline processes for the system are understood and the basic rules governing the system are considered in each management decision step.

The benefits of enhanced floodplain connectivity are well-documented. Increasing the distribution of flood waters into overbank areas or inter-connected off-channel systems reduces site-specific erosion problems, distributes sediment into more varied and long-term storage scenarios, balances sediment transport/deposition further reducing erosion issues, encourages the replenishment of fine grained topsoil sediments into riparian areas thereby encouraging healthy riparian vegetation systems, dissipates floodwaters and floodwater energy by storing peak volumes in overbank areas, and encourages more long-term groundwater recharge of overbank areas and wetlands thereby improving longer term returns to the main channel to sustain low flows. Improvements in floodplain storage cannot be gained by implementing only one project at an isolated location. Doing so often results in relaying the problem being addressed to a different location in the stream. Desired benefits are more likely to be realized if the approach is applied and measured over longer time frames and at the reach scale.

Natural channel development follows a cycle of incision and widening. The channel cuts down into accumulated sediments leading to subsequent erosion of the channel banks. Continued down-cutting leads to the gradual widening of the active channel as the toe of the banks are eroded and more sediment is contributed to the system. As the channel widens the hydraulic geometry changes, and the sediment transport capacity of the channel is exceeded in relation to available flow, causing sediment to accumulate in complex layers across the developing floodplain. As sediment accumulations re-shape the floodplain landscape, the hydraulic geometries are again re-defined and the process of incision may again initiate, starting the cycle over again across a more complex floodplain surface (Simon and Hupp, 1986). The introduction of vegetative materials (i.e., large woody debris) adds additional complexity to the model as it acts to re-direct flows and sediment materials across the floodplain.

The longer-term effect of the large quantities of mobilized woody debris (i.e., eroded from the banks) and riparian colonies throughout floodplain areas is to trap and store sediments in islands or rafts with complex horizontal and vertical geometries. Localized problems with erosion can occur around accumulations of large woody debris and log jams, but the net reach scale effect is to provide a naturally structured (but not necessarily linear) matrix that holds the sediment in place and slows the movement of the sediment laterally or downstream. This matrix works over long periods of time, corresponding to the colonization of vegetation around accumulations of sediment materials at log jams and peak flow histories. For instance, a log jam may form at a given location causing the development of a gravel bar downstream in the hydraulic shadow of the jam. As the gravel bar builds in volume (i.e., length, width, and height) it may start to gain a vegetative cover of trees, shrubs, and/or grasses. The sediment that continues to accumulate within and around the island is "temporarily" stored there until the jam releases or the island erodes in response to some flood event.

This cycle may occur on the scale of take 10's of years or more, and is strongly influenced by peak flow events.

A series or larger network of large woody debris within a riverine system can act essentially as a large collective grade-control structure(s) that can hold and/or release sediment to downstream reaches. A large system of woody debris distributed over many miles of stream can trap and hold an large volume of material. The same concept applies to traditional dam structures in river systems. Removing a dam from a stream or river can result in mobilization of the upstream accumulated sediment into downstream reaches. The large scale removal of large woody debris from a riverine system can also result in the large scale mobilization of the "accumulated" or stored sediments into downstream areas. Although this can occur naturally in response to peak flows or other events, it can also occur in response to historical land and channel management practices, thereby speeding up the timeline of individual components of the channel evolutionary process.

This is essentially what has happened on the Big River with the implementation of the stream clearance work by the Washington State Department of Fisheries in the 1950's. The large scale removal of woody debris in the Highway, Solberg Creek, and lower Boe Creek Reaches has resulted in a reduction in storage of sediments and a loss in complexity of woody debris structure throughout the main channel and floodplain. This has lead to gradual incision of the channel, and a corresponding drop in the channel profile elevation. In areas where riparian corridors are not in place, this has lead to increased bank erosion. In areas where riparian vegetation is in place, the channel has continued to incise. The overall effect in some places has lowered the channel as much as 6-feet (Golder, 2005b).

Where the main channel has dropped in elevation, the tributary stream channels will also drop in elevation. The effect therefore spreads to tributary basin areas where networked wetlands may exist. Long-term lowering of the main channel and corresponding tributary channels can have the effect of lowering the adjacent floodplain groundwater table, and essentially developing a better drained floodplain. This has the greatest impact on wetland areas connected to the main channel and/or its tributaries.

The following outlines specific recommendations for future actions within each of the project reaches incorporating the information and data reviewed as apart of this assessment and as outlined in the discussion above.

3.4 Discussion of Potential Actions

The following discussion incorporates the data and information outlined in previous sections and develops the ideas for potential future actions in each reach of Big River. The discussion is generally organized around improving and/or enhancing floodplain connectivity, increasing and/or maintaining floodplain groundwater storage, and wetland storage in each reach. These two issues were identified through review of the existing information and other literature on riverine and floodplain systems as key to restoring long-term natural fluvial geomorphic processes.

3.4.1 Headwaters Reach

Floodplains in the Headwaters reach are limited in size due to the narrow, steep, and rugged terrain. The scales at which improvements in floodplain connectivity can be achieved are varied, but generally correspond to the predominately small stream networks throughout the reach. Although the scales are different from the broad floodplains of the lower valley, the basic concepts of channel process and function remain the same. Changes in stream function are primarily influenced by changes in land use and by patterns of natural disturbance. Changes in basin vegetation cover caused either by changes in land use, vegetation cover or natural disturbance can result in increases in peak stream flow and run-off volumes. The increase in road networks can increase the delivery of fine grained sediments to streams.

Recent trends in restoration and improvement of floodplain connectivity in contributing basin areas are moving toward abandonment of un-used forest roads and restoration of stream crossings where large fills and/or culverts were installed. The USFS abandonment of forest roads policy is to restore the road section to pre-disturbed contour and graded condition. For instance, where roads were cut into side slopes, the cuts are filled. Where roads are constructed of fill, sections the material are removed/regraded to match the original grades. Road abandonment policies accepted by DNR for RMAP work typically focuses on restoration of forest roads to undisturbed conditions where unstable fill exists or where there is a clear environmental hazard. Large fills at culverted road crossings can be removed and the original stream gradient restored through the crossing. Fish passage issues may addressed where road crossings limit upstream access. There are also situations where road embankments have created wetland areas where ponded water accumulates on the upstream side. These areas should be identified and preserved where they exist, and enhanced to the extent necessary to maintain the created wetland resource.

These types of projects require a comprehensive look at the location, quality, and conditions at individual sites. Because there are typically a large number of candidate sites, an inventory is required to identify, evaluate, and prioritize the sites so that resources can be effectively applied to the project area.

Therefore consideration may be given to the development of an inventory of the existing road network, tributary streams, and historical land use practices in the Headwaters reach. The inventory would provide a basis for assessing the feasibility of proposed enhancement opportunities. The inventory would focus on gaining a better understanding of the extent of the road network, streams, wetlands, fish passage, etc., and how they may be connected to within the Headwaters area. This type of site specific data can support development of road abandonment and maintenance plans, as well as develop a better understanding for land owners on how to manage road networks over the long-term.

The Road Maintenance and Abandonment Plan (RMAP) program focuses on improving existing road networks on private commercial forest and state forest land. Priorities for work include the following:

- Removing fish passage blockages, on roads affecting most habitat first, usually from the bottom of basin and working upstream.
- Preventing or limiting sediment delivery/mass wasting.
- Correcting drainage or unstable sidecast where mass wasting "could deliver to public resources or threaten public safety.
- Preventing road drainage to typed waters.
- Repairing or maintaining stream parallel roads, emphasis on minimizing/eliminating water and sediment delivery.
- Minimizing the interruption of surface and subsurface water.
- Repair/maintenance work that can be done with maximum operational efficiency.

Much of the Headwaters Reach has been mapped as susceptible to landslides under Clallam County's Critical Areas Ordinances (CAOs; Figure 3-7). However, the Clallam County Critical Areas ordinance does not apply to forest practice lands that are being used for Class I, II, or III forest practices, as these are under jurisdiction of the Forest Practices Act. The Forest Practice Rules provides protection of areas within Riparian Management Zones and protected buffers along streams.

Any lands that are cut for harvest and are not intended to be reforested because they will be used for urban or residential development are classified as Class IV general forest practices (WAC 222-16-050(2)). When this forest conversion occurs, there is a transfer of jurisdiction from the state (forest practice rules) to the county (comprehensive plan and zoning) that occurs at the time when the land is no longer used for forest practices. To complete a Class IV conversion, an application is filed with the Forest Practice Board, the SEPA lead agency is determined, SEPA is conducted, and then, if approved the county or city changes the land use designation of the property. Once a forest conversion has been completed, local regulatory protections to apply to the land, including Critical Areas Ordinances and zoning regulations. However, there are gaps in the protection of these parcels. The Forest Practices Act exempts land clearing on lots smaller than two acres with less than 5,000 board feet of timber removed.

It is assumed that the lands in the Headwaters Reach of Big River are Class I, II, or III forest lands, are not subject to county ordinances, and are governed by the Forest Practices Act.

3.4.2 Falls Reach

The Falls Reach is a transition reach between the Upper and Lower Basin areas. The falls act as a natural fish barrier and as a natural grade control for upstream versus downstream channel dynamics. The reach is very dynamic and responsive to in-channel changes (i.e. woody debris, sediment loading, etc.). Aside from maintaining the function of the falls reach, no additional in-channel work is proposed in this reach. Continued monitoring of the reach for physical changes in channel morphology is recommended to provide a comprehensive record of the Big River system and to support work in other reaches.

3.4.3 Boe Creek Reach

The Boe Creek Reach is one of the more dynamic river reaches within the project area. The long-term reduction in riparian vegetation through development of agricultural land uses has lead to incision and increased bank erosion. Channel migration studies document areas where lateral erosion problems exist (Figure 3-1). The bank erosion issues are contributing fine grained sediments into the river system, and leading to continued damage of agricultural properties. Any future planning efforts should recognize this reach has the highest density of residential and agriculturally developed areas within the project area. As such, any proposed enhancement work in this reach should fully incorporate land owner concerns and balance enhancement efforts with existing land uses.

Enhancement opportunities in the Boe Creek Reach should recognize the highly dynamic response mechanisms that are at work in the river channel. The propensity for lateral erosion in the reach makes it a candidate for possible bank stabilization projects. Proposed bank stabilization work should consider both up- and downstream impacts and incorporate the reach geomorphic characteristics specific to this reach. For instance, increased roughness (i.e. installation of woody debris) in active channel areas may lead to increased lateral bank erosion due to the lack of available riparian vegetation and generally unstable banks. Therefore, restoration efforts should focus stabilizing banks through soft-engineering approaches or improving riparian vegetation cover in overbank areas along the river channel through conservation programs such as the Conservation Reserve and Enhancement

Program (CREP), Conservation Reserve Program (CRP), and other programs of the United States Department of Agriculture and/or conservation easements (Appendix 3-D). These are typically administered and facilitated through the local conservation district.

- **Conservation Reserve Enhancement Program**. Unique state and federal partnerships allow landowners to receive incentive payments for installing specific conservation practices. Through the CREP program, farmers can receive annual rental payments and cost-share assistance to establish long-term, resource conserving covers on eligible land. This program is designed to re-establish riparian buffers along streams, especially those with ESA-listed salmon species. Compensation to the landowner consists of several components including:
    - Annual rental rate (typically $135-$423 per acre, but varies widely);
    - Signing incentive ($10/acre/full contract year. e.g., 100 acres for 10 years would generate a signing incentive payment of $10,000); and,
    - Other incentives and cost sharing such as for fencing costs, re-establishment of riparian vegetative cover, and others.
- **Conservation Reserve Program -** The Conservation Reserve Program is a voluntary program for agricultural land owners. Landowners receive annual payments by planting vegetation on idle, highly erodible agricultural lands. The land must be highly erodible and have a history of non-irrigated cropland tracts for at least four of the most recent six years. Since the payout per acre is low (annual rental rates typically run $160-$220 per acre), landowners must have many acres to make this program worthwhile. Enrollment is highly competitive, and landowners would be bidding against each other across the country.

Wherever possible, enhancement projects should be initiated where landowners are interested in supporting and maintaining such projects. Recruiting cooperative landowners and establishing a sponsor for the project is the key to the long-term viability of enhancement projects. Continued education and outreach programs that explain the benefits and long-term returns from enhancement work will help to encourage landowners to participate in continued enhancement efforts.

3.4.4 Solberg Creek Reach

The Solberg Creek Reach is a transition reach between the upstream dynamic and laterally erosion prone Boe Creek Reach, and the downstream Highway Reach. The Solberg Creek Reach most likely represents a template for what the Boe Creek reach used to look like before the riparian vegetation was removed. This reach is relatively sparsely inhabited with few residential homes. Property ownership is widely held. This reach offers excellent potential for development of woody debris enhancement structures, with a reduced risk of impacting up- or downstream developed properties.

The morphology of the Solberg Creek Reach allows for installation of in-channel structures. Enhancement efforts should incorporate complex woody debris structures with off-channel and back-channel habitat areas where possible. Existing riparian vegetation in overbank areas will provide excellent cover and enhance the rapid return on investment in project development, design, and installation in the form of habitat value. Development of increased woody debris complexes through this reach over the long-term should improve connectivity between the main channel and overbank areas. In particular, there is the opportunity to expand wetland areas in the lower portion of the Boe Creek Reach (Figure 3-1) and further downstream into the Solberg Creek reach through development of increased roughness (i.e., installation of woody debris).

3.4.5 Highway Reach

The Highway reach is influenced by the presence of the Hoko-Ozette Road running along the rightbank (north) side of the main river channel. The channel through this reach experienced some of the greatest extent of removal of large woody debris during the 1950's (Figure 3-1), resulting is a net loss of in-channel diversity and subsequent down-cutting and incision of the stream profile. The channel has slowly lost connectivity to the adjacent floodplain as it has cut down and incised into the finer grained material prevalent throughout the reach. Additionally, the net cumulative effect of armoring the road embankment throughout this reach will encourage the river to remain along the toe of the road embankment and further reduce connectivity with the rest of the active floodplain.

The primary goal for this reach is therefore to slow the incision process and possibly, over the long-term, restore connectivity between the channel and floodplain. One approach for increasing roughness in the channel and floodplain is through the introduction of large woody debris, in essence reversing the work completed by the stream clearance efforts in the 1950's. This approach would work best if implemented at a reach scale. Development of more woody debris structures throughout the reach would have a net increase in roughness and develop a matrix of material that could trap sediments in the form of bars and islands. The diversity of flows around individual structures would also increase resulting in more complex and higher quality habitat areas. Increasing roughness in the channel and floodplain would force flows to interact with woody debris, thereby developing more varied flow regimes around individual structures. The long-term effect of this at a reach scale would create varied thalweg profiles (i.e., scour pools, runs, pool/riffles sequences, etc.) around roughness features. This increased complexity in flow regime especially at low-flows would enhance habitat diversity and quality.

An individual woody debris structure would over time establish a corresponding depositional area/bar/island located in its downstream shadow. This depositional area will slowly establish a vegetative cover and stabilize as the vegetation matures and take hold. Localized scour and erosion should be anticipated around individual woody debris structures as the channel responds to the initial placements. The sediment and other woody debris material stored in this "structure" may change/move downstream in response to peak flow, but the net effect distributed over the entire reach will diversify the storage of sediments across the floodplain and reduce continued degradation of the channel.

Numerous wetland complexes are evident in this reach throughout the north floodplain of the river and along Trout Creek (Figure 3-1). Restoring, or at least stabilizing the channel against continued down-cutting can only improve the viability of these existing wetland areas and possibly develop, enhance, and expand them in the future.

3.4.6 Lake Reach

The Lake reach has remained essentially unchanged in recent history and continues to be influenced by back-water from the lake. Numerous log jams were identified during the stream clearance work completed in the 1950's, but little was actually removed due to the difficult access and equipment limitations of the day. The conditions are largely un-changed today, making implementation of project in the Lake reach still difficult. Habitat may be enhanced by connecting the main channel to off-channel areas or possibly to historical channel networks. The back-water effect from the lake may provide inundation of developed off-channel areas and also encourage rapid development of riparian cover. Review of the LiDAR data will support identification of project sites (e.g., old channel alignments, swales, relic channels, or sloughs). The focus in this reach is to use the back-water condition of the lake environment to develop corresponding habitat enhancement opportunities.

3.5 Data Gaps

Much useful data exists and was reviewed in the execution of this assessment. A limited but useful record of historical photographs was obtained from Kramer (1953) and recent photographs provided by the Makah Tribe. The collection of additional photographs is currently being undertaken by Mr. Ed Bowen. Recommendations relating to data gaps include: the continuation of on-going continuous data collection (e.g., stream gaging); periodic synoptic data collection (e.g., air photos); and, detailed surveys (e.g., channel profiles).

3.5.1 Stream Gaging

The initiation of a stream flow gaging station (Figure 3-1) by the Makah Tribe is the first and one of the most important efforts in developing an understanding of flow regime in the Big River basin. Continued stream flow monitoring should be a priority for the future. Maintenance of the current continuous stream gaging should be the priority. Additional stream gaging stations located on tributaries to the Big River would further develop a better understanding for contributing flows in Trout Creek, Solberg Creek, and Boe Creek to the main river channel. Additional stream gaging stations should provide continuous data collection, so that a corresponding continuous flow record can be developed. In the absence of continuous stream gaging stations, spot measurements of streamflow are very useful.

3.5.2 LiDAR (Light Detection and Ranging)

LiDAR aerial flights completed in 2003 only extended approximately 8 to 9 miles upstream of the mouth of the Big River (Figure 3-2). Extending the existing 2003 LiDAR database upstream to incorporate the entire Big River basin through approximately RM 15 would provide a useful dataset in the design of remediative actions (e.g., locating large woody debris installations). Additionally, we understand that the algorithms for the previously completed LiDAR data require re-calibration to rectify inaccuracies in the data. We recommend these accuracy issues be addressed and the data updated as needed.

3.5.3 Aerial photos

Aerial photographs are most valuable in the historical context when efforts are initiated to look at long-term changes in basin characteristics, or to look at changes over time at a particular location. We recommend the existing database of historical aerial photos including 1994, 2000, and 2003 (Figures 3-3 through 3-5, respectively) be expanded to include updates at regular time intervals (e.g., every 10 years). Where possible these photos should be in color and provide stereo-pair sets for future analysis and photo interpretation efforts.

3.5.4 In-channel elevation data/bathymetry

The availability of LiDAR and aerial photos provides a resource for viewing and assessing surface features throughout the basin. Photo interpretation can also be used for rough assessments of vertical channel and floodplain changes through stereo pair evaluations and analysis of geomorphic characteristics. But, the highest quality source of data for quantification of vertical channel changes is through recording of historical elevations at known locations over time. This report talks about changes in channel morphology that relate to vertical channel movement and/or changes in channel section geometry. An effective way to track changes in channel geometry is to record those changes over time through site surveys. Surveys can consist of (in order of increasing cost and usefulness):

- Cross section surveying of cross-sections at fixed reference locations;

- Surveying of channel profiles along thalweg alignments or other channel alignments (i.e. relic channels, swales, back-channel areas, etc); and,

- Full bathymetric scanning/mapping of channel bottom areas.

Development of a database of channel survey information will help explain or support geomorphic characterizations and track trends in channel behavior.

A likely start for the database is at the flow gaging station location (Figure 3-1). We recommend that a survey benchmark be established so that continued stream gaging measurements can be tied to a known elevation datum. This will allow for the long-term comparison of channel geometries relative to flow histories at this location. Channel survey data will also provide a basis for completing hydraulic assessments and engineering analysis.

Additional channel surveys are recommended for the extent of the project area. Priorities should be given to the reaches below the Falls in developed areas and areas/reaches where projects are proposed. Survey should be coordinated to the elevation datum used in the LiDAR flights. Surveys can consist of detailed channel bottom contouring, channel profiles measured along the thalweg, or cross-sections taken at known locations throughout the project area. The latter is most common. Successive channel surveys would readily show possible trends in channel change (either degradation or aggradation) at those locations, and a network of channel cross-sections throughout the project area would provide a reach based comparison of channel characteristics.

3.6 Summary

The following offers a bulleted summary of key enhancement opportunities in each reach. Recommendations common to all reaches include:

- A reach scale approach to analysis and projects.

- Monitoring (aerial photos, surveys, stream flow data gathering, etc).

- Appropriate implementation of riparian zone Critical Areas Ordinances, as applicable.

3.6.1 Headwaters Reach

Opportunities for enhancement in the Headwaters Reach are focused on evaluating the existing resource and developing plans for best long-term management of diverse relationship between existing road networks, small tributary streams, and corresponding wetland areas. The following summarizes the key actions in this reach:

- Comprehensive road/drainage inventory and implementation of Road Maintenance and Abandonment Plans (RMAPs) in accordance with the Forest Practices Act.

3.6.2 Falls Reach

The Falls Reach is a transition reach between the Upper and Lower Basin areas. No specific enhancement activities are proposed but the reach should be monitored in conjunction with the other work completed in the basin to track possible changes in the morphology of this reach.

3.6.3 Boe Creek Reach

The Boe Creek Reach is one of the most altered and more dynamic river reaches within the project area, and has the heaviest developed residential community. Any efforts to implement restoration activities in this reach should recognize the importance of the local residents and find the balance between habitat enhancement and existing land use. Long-term enhancement opportunities in this reach are summarized as follows:

- Soft-engineered bank stabilization (e.g., anchored large woody debris and strategic riparian plantings, versus rip rap rock).
- Conservation programs such as CREP and/or conservation easements (Appendix 3—D).
- Recruitment of landowners for implementation of enhancement projects.
- Appropriate implementation of riparian zone Critical Areas Ordinances.

3.6.4 Solberg Creek Reach

The Solberg Creek reach is a transition reach between the upstream located dynamic and laterally erosion prone Boe Creek reach and downstream located Highway reach. This reach offers excellent potential for development of woody debris enhancement structures, with a reduced risk of impacting up- or downstream properties. Additional benefits include enhancement of wetlands function in overbank areas. Long-term enhancement opportunities in this reach are summarized as follows:

- Soft-engineered bank stabilization .
- Increase large woody debris/roughness features in channel and floodplain.
- Appropriate implementation of riparian zone Critical Areas Ordinances.

3.6.5 Highway Reach

Enhancement efforts in the Highway reach should focus on increasing roughness in the main channel corridor and overbank floodplain areas, and incorporate considerations into planning and design to minimize the potential for the channel to relocate along the Hoko-Ozette Road. Long-term increases in channel and floodplain roughness will slow or reverse historical down-cutting trends (channel incisement/degradation), improve connectivity between the main channel and the floodplain, and enhance wetlands function in overbank areas. Long-term enhancement opportunities in this reach are summarized as follows:

- Increase large woody debris/roughness features in channel and floodplain.

3.6.6 Lake Reach

Habitat enhancement opportunities in the Lake reach should look for connecting the main channel to off-channel areas and historical channel networks. The back-water effect from the lake may provide inundation of developed off-channel areas and also encourage rapid development of riparian cover. Long-term enhancement opportunities in this reach are summarized as follows:

- Install large woody debris/roughness features in channel and floodplain in conjunction with development of off-channel habitat areas.